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Hydrologic variables influencing invasion of brook trout

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FINAL REPORT

Report Prepared for
USDA Forest Service, Rocky Mountain Research Station
Research Joint Venture Agreement 05-JV-11221659-199

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1. INTRODUCTION

As a part of the complex project of analysis of hydrologic variables influencing invasion of brook trout development of complex database was performed. One of the elements of database is related to collection and analysis of hydrologic characteristics of analyzed sites and development of metadata for selected gaging stations located in the Western United States.

1.1. Download of Mean Daily Streamflow Records and Assembly of the Database

In the analysis of hydrologic variables influencing invasion of brook trout information from 406 USGS sites were used. These sites are located across 7 states in the interior Western United States, (Figure 1). Distributions of sites are different from state to state. Greatest number of sites is located in Montana, Colorado, Idaho and Wyoming.

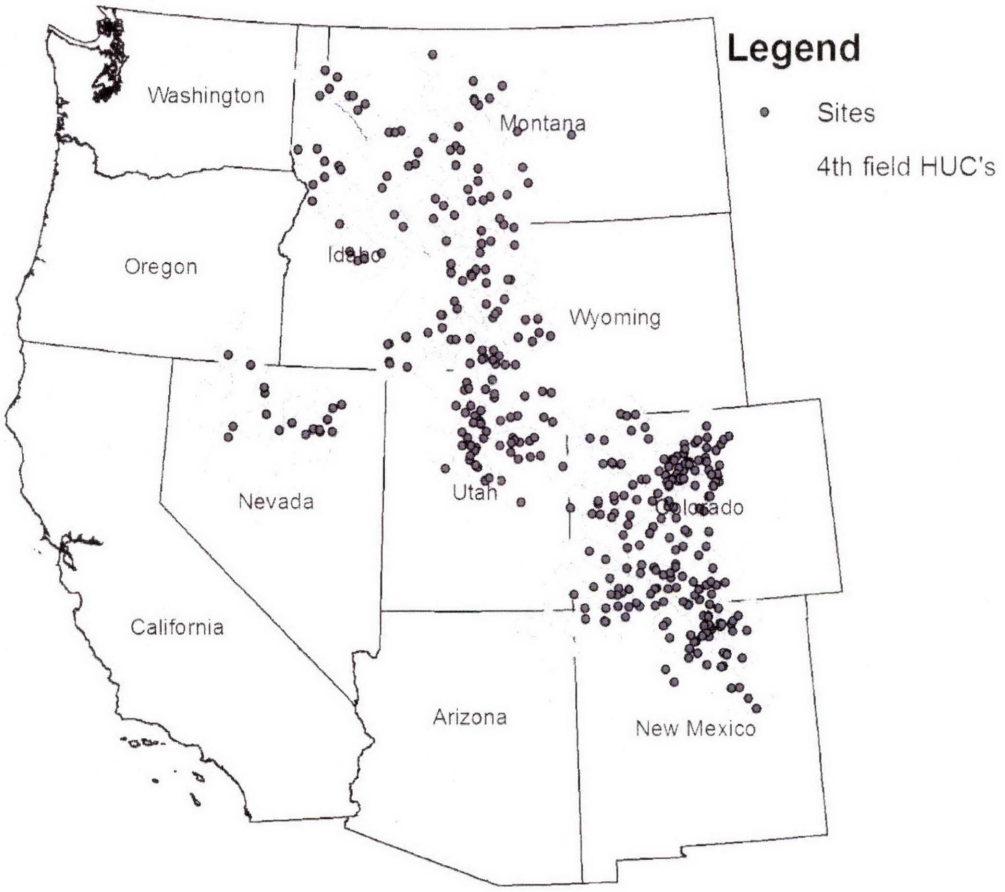


Figure 1. Location of analyzed sites in the Western United States

For each of the sites relevant information were collected from the USGS Site inventory web site (http://nwis.waterdata.usgs.gov/nwis/inventory), (Table 1).

Table 1. Relevant information downloaded for each site presented in metadata

Name	Explanation
SITE_NO	Site identification number
STATION_NM	Site name
DEC_LAT_VA	Decimal latitude
DEC_LONG_V	Decimal longitude
COORD_ACY	Lat/long accuracy
DEC_COORD	Decimal datum
STATE_CD	State code
COUNTY_CD	County code
ALT_VA	Gauge datum (feet)
ALT_ACY_VA	Altitude accuracy
ALT_DATUM	Altitude datum
HUC_CD	Hydrologic unit code
DRAIN_AREA	Drainage area (mi^2)

In the next step, daily mean streamflows were downloaded from the USGS's "Daily Streamflow for the Nation" web site (http://nwis.waterdata.usgs.gov/nwis/discharge). For each site following information was observed and entered into the database:

- Start date – starting date of discharge measurements
- End date – last date of available records
- Number of data – total number of available data
- Final year – final year of available data
- Data ranges – ranges of available records

All the downloaded data are available in the metadata table of Access database.

1.2. Assessment of the quality and reliability of flow data

The hydrographs for 406 sites during observed periods were plotted. In the scope of analysis reliability of available data, the missing data i.e. missing periods of recording are registered.

Also, all sites with hydrographs altered in any way were marked as the inappropriate for the analysis, e.g. hydrographs presented in Figure 2.

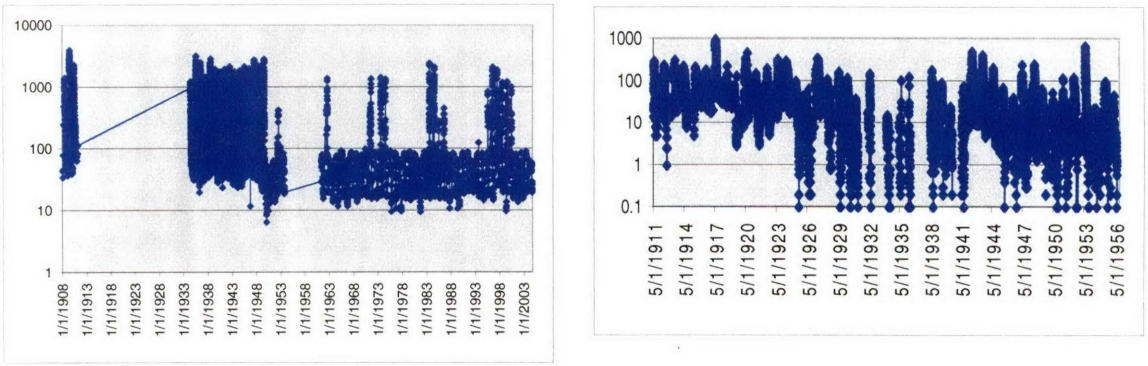


Figure 2. Examples of altered hydrographs:
a) Colorado River nr. Granby, b) Flatwillow Creek nr. Flatwillow MT

All sites located below or above the reservoirs, or on canals, were marked as well.

Attempt was made to find maps with irrigation districts for all 7 states, but only State of Idaho' Department of Water Resources had a map of irrigation districts available (http://maps.idwr.idaho.gov/mapall2/viewer.htm). Using this map, 6 sites, mostly in the Snake River Plain, were excluded.

The idea of locating dams in the area was abandoned after the shapefile with dam locations was downloaded from the National Registry of Dams (http://crunch.tec.army.mil/nid/webpages/nid.cfm) and placed on the shapefile with sites. Region has too many dams, and that information probably would eliminate almost all of the sites used in the analysis.

As the result of this initial analysis 258 sites are recommended for further analysis, and those are marked as OK in the "Good to use?" column of the database.

In coordination with Forest Service the statistical analyses of flow data for selected sites were performed and the database for analysis brook trout invasion was established. Obtained database was used in this report for analyses of influence of selected geographic parameters on the hydrologic variables.

2. Analysis of selected hydrologic variables

The aim of this analysis is attempt to assess the influence of some geographic parameters and drainage area on the timing of some characteristic flows, as well as their duration for the characteristic periods of year. For analyzed the fish population three periods are important for their life:

- Eggs period – October-March
- Fry period – April – July 15
- Total – October – July 15.

The analysis was performed for three sets of response variables:

- Median flood timing (Julian date) for period of record
- 50 or 75% inter-quartile range for timing of flood
- Annual variation in years with a flood (% years)

For each variable relationship was developed against the three main parameters:

- Drainage area
- Gauge latitude
- Gauge longitude.

All analyses were performed for 1.5, 2.5, and 5 year return periods determined by Forest Service

2.1. Analysis of median flood timing for selected time periods

The established relationships, regardless the return period indicate similar trend for each of considered time periods, Appendix 1. For analyses were used all available data from all sites, and data from sites that satisfied selected criteria.

For eggs period, the median flood timing shows the highest variability from site to site, and does not depend from analyzed parameters, Figure 3. It can be seen that both datasets are showing very similar characteristics, Appendix 1. For some gauge stations are evident similar flood timing that coincides with time of occurrence of fall and spring rains.

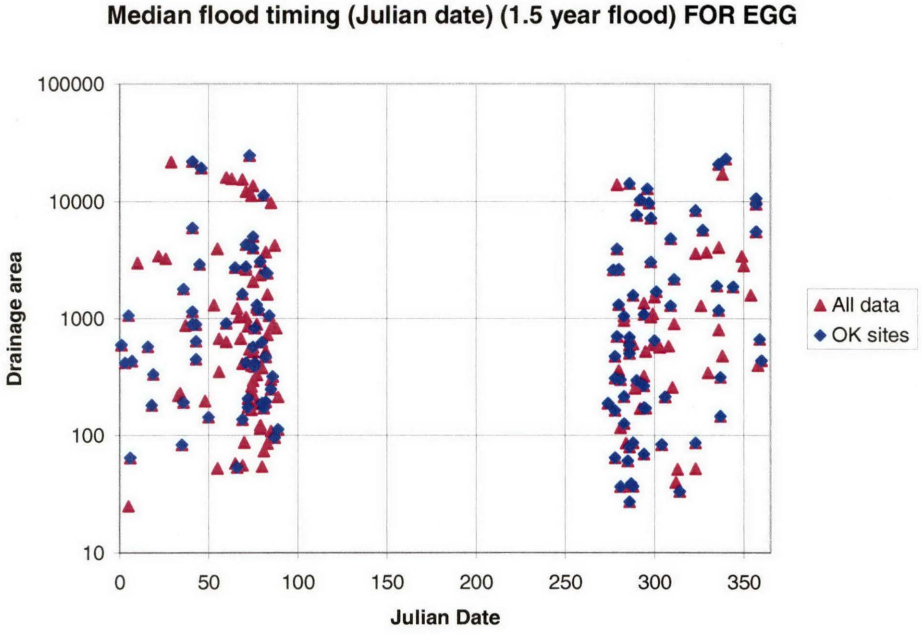


Figure 3 Median flood timing for the 1.5 year return period for the eggs period

For fry and total periods, the median flood timing for all considered sites is also independent from analyzed parameters. Opposite from eggs period, the median flood

timings are concentrated around 150th day in the year (~May 30), Figure 4. The similar flood timing for all analyzed sites coincides with facts that characteristic flow discharges at all analyzed streams are consequence of significant snow melt at the end of May. Same conclusions can be obtained from relationships established for 2.5 and 5 year return periods, (Appendix 1). In order to show similar trend of analyzed variables, the diagrams for all three return periods were plotted on the same diagram for eggs, fry and total period (Appendix 2). That means that site location (latitude and longitude), as well as, drainage area have no influence on considered hydrologic variables.

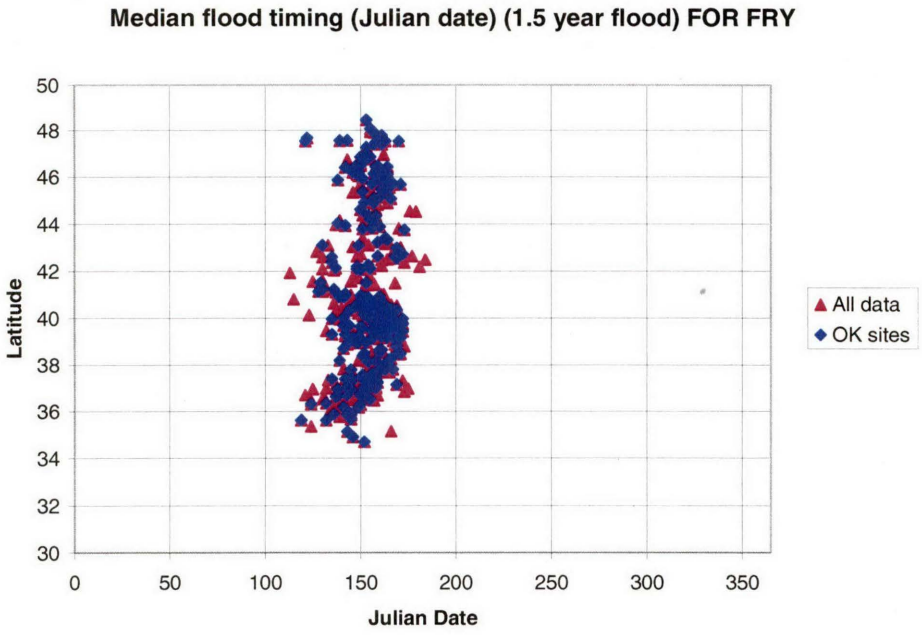


Figure 4 Median flood timing for the 1.5 year return period for the fry period

2.2. Analysis of 50 and 75% inter-quartile range for flood timing

Relationships are developed for three return periods and presented in Appendix 3.

Trends are similar to those obtained for median flood timing. Minimum, maximum and average ranges of days between 50 and 75% flood timing are presented in Table 2. Largest differences are observed for eggs period, which, once again, confirms higher variability in discharges in October-March period.

Table 2 Min, max and average ranges between 50 and 75% flood timing

		1.5 year return period (range, in days)	2.5 year return period (range, in days)	5 year return period (range, in days)
EGGS	Min	0	0	0
	Max	145	136	32
	Average	20	11	6
FRY	Min	6	5	3
	Max	34	29	32
	Average	11	10	8
TOTAL	Min	6	5	3
	Max	28	55	53
	Average	12	10	9

2.3. Annual variation in years with flood

In the case of annual variation in years with flood, some variability is observed during the eggs period from site to site. Percentage of years with floods (1.5, 2, 5 year events) is independent from analyzed parameters. For fry and total time period there is no significant variability in comparison to analyzed parameters, but results did vary among return periods. For 5 years return period the percentage is smallest, Appendix 4.

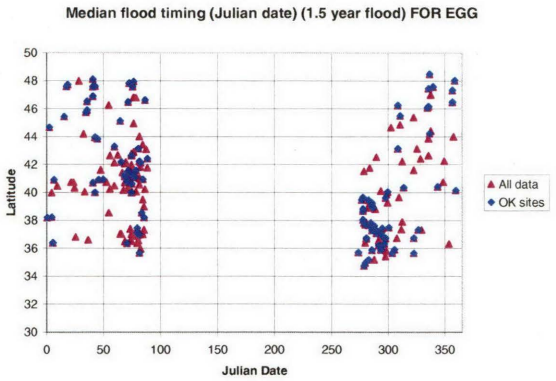
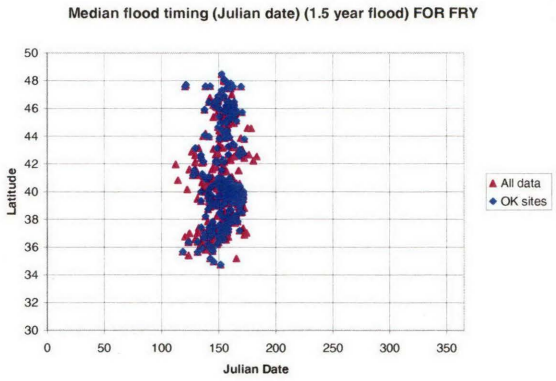
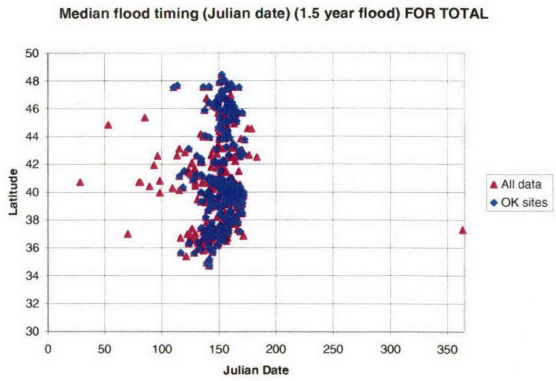
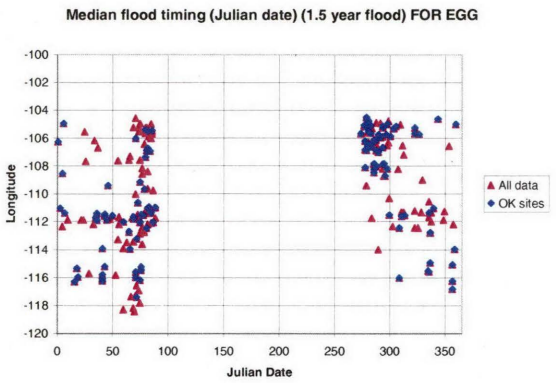
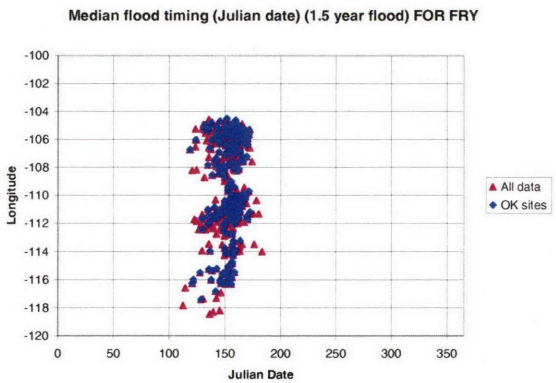
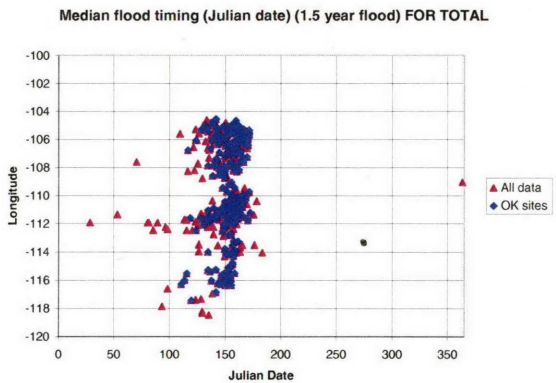
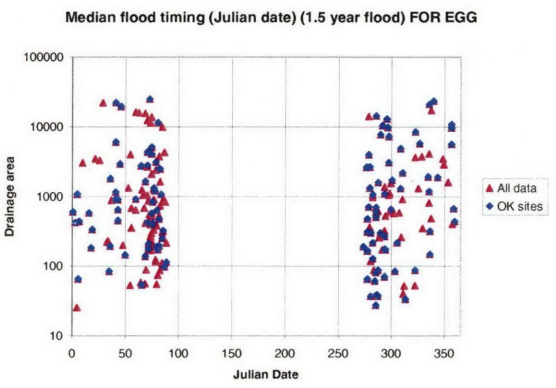
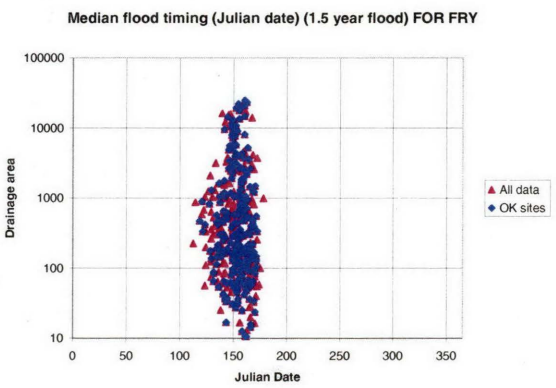
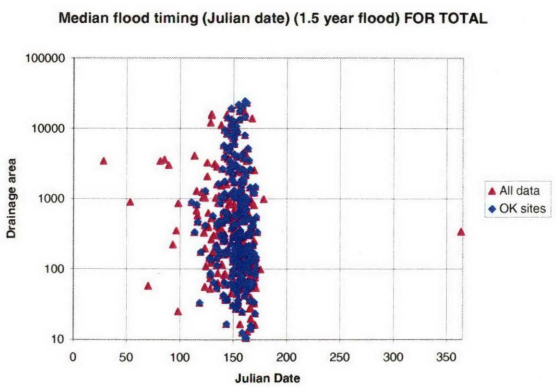
2.4. General remarks

Based on the performed analyses it can be concluded:

- Selected parameters (gauge location, and drainage area) practically have no influence on analyzed hydraulic variables;
- Median flood timing for analyzed gauging stations for eggs period varies within a whole period;
- Median flood timing for fry and total period coincides about 150 day (end of May);
- Return period practically have no influence on the median flood timing.

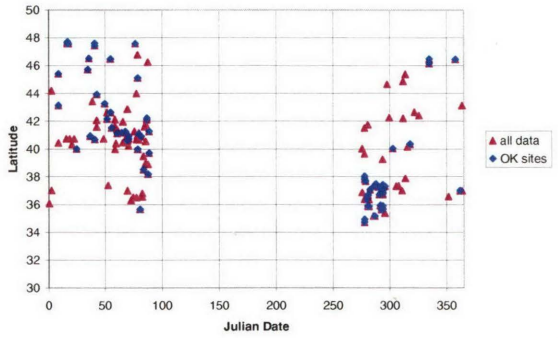
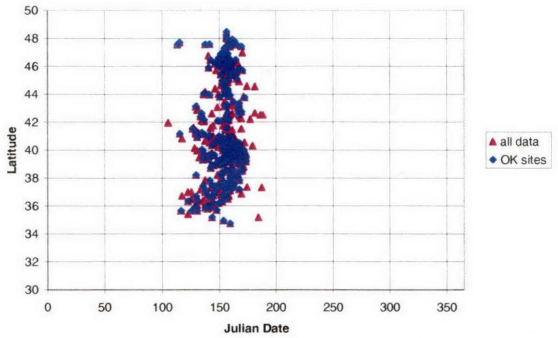
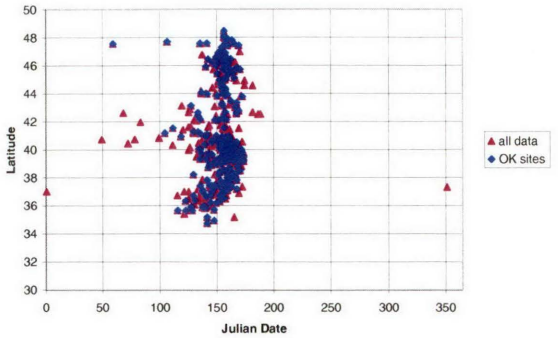
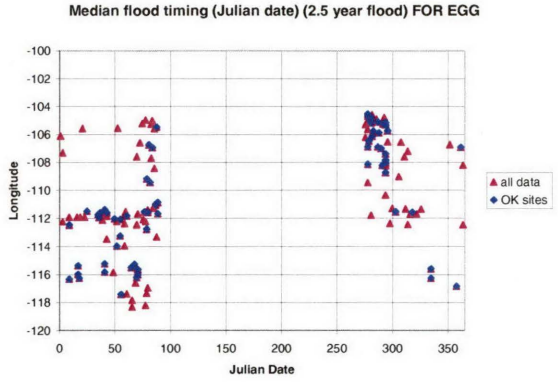
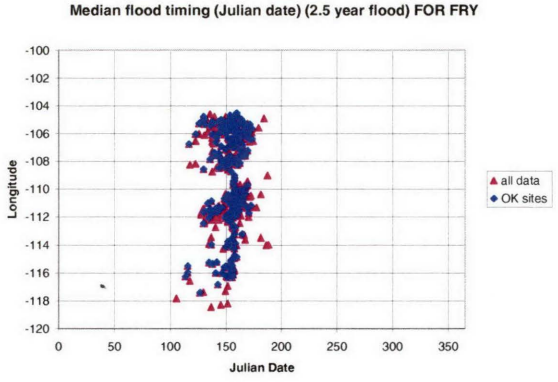
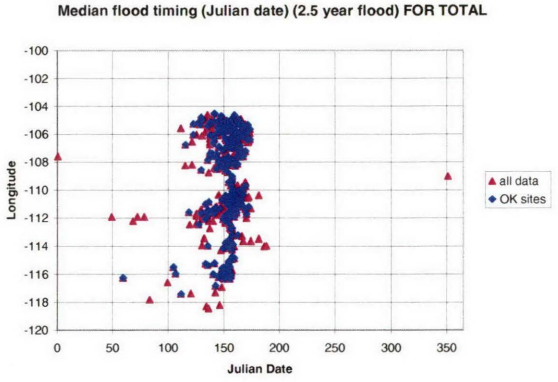
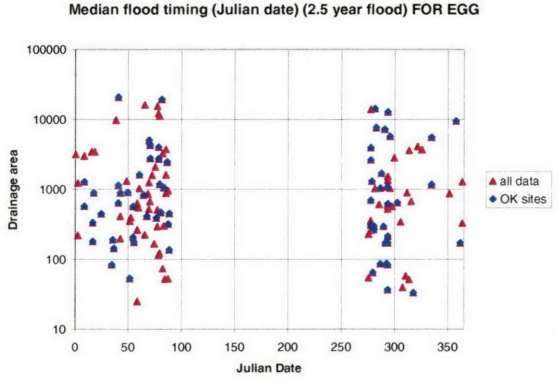
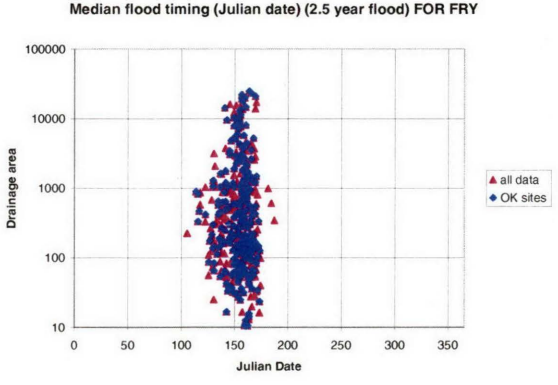
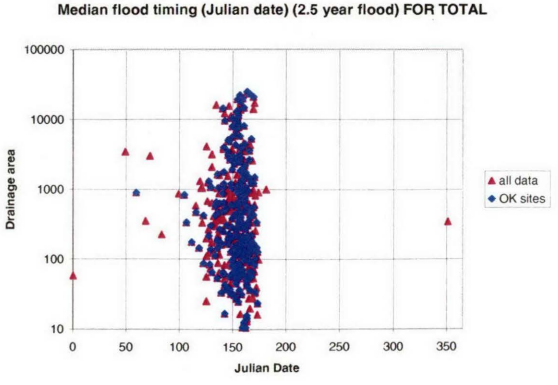
APPENDIX 1

P50_Q15 – Median Julian Day for a 1.5 year return period

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

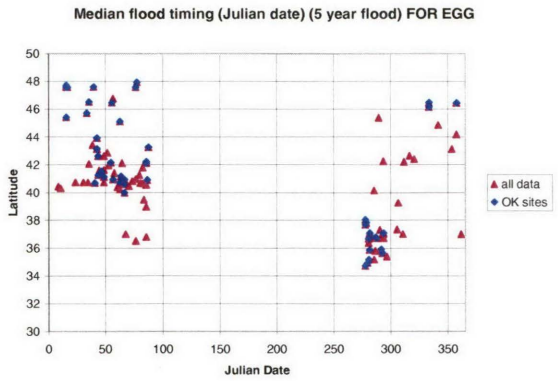
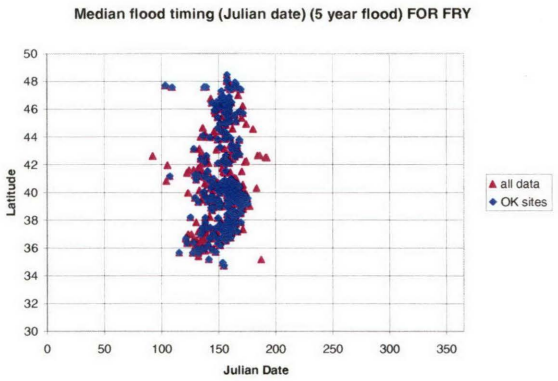
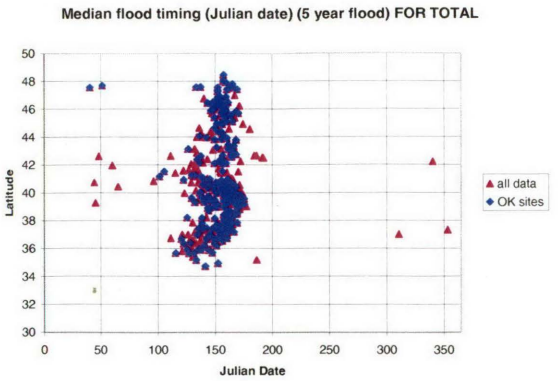
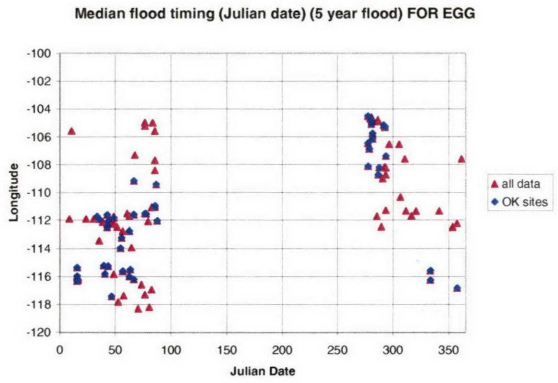
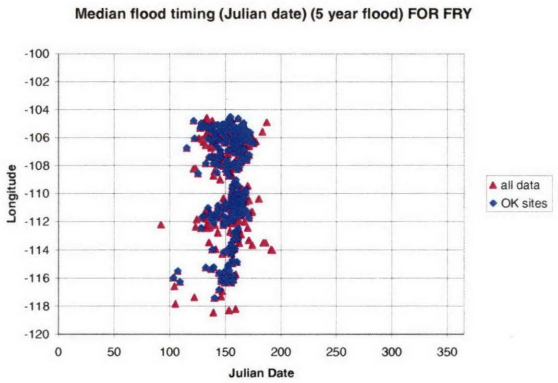
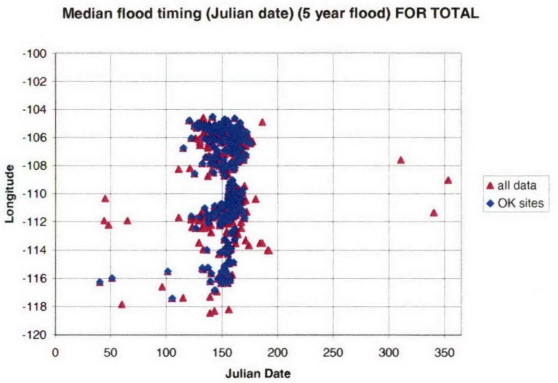
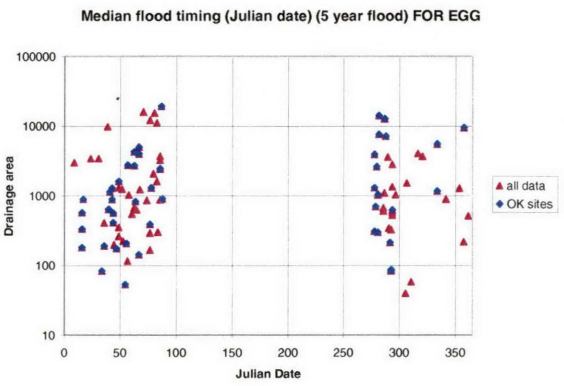
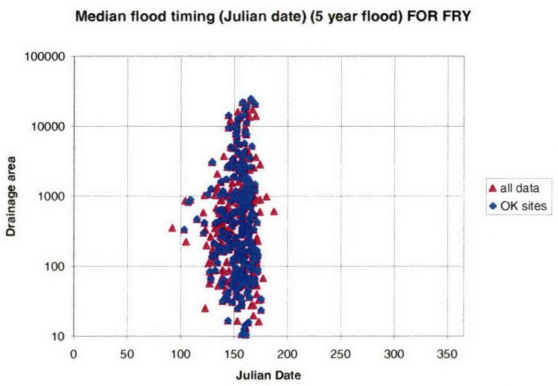
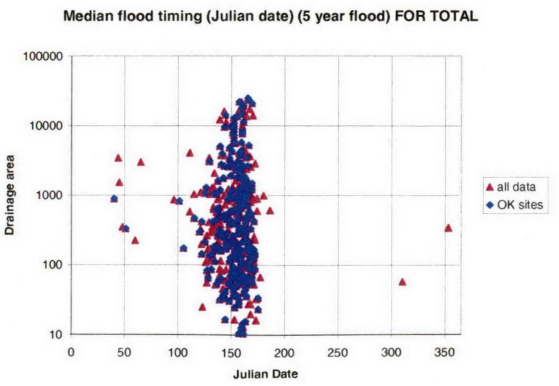
Median flood timing (Julian date) (1.5 year flood) FOR EGG
Median flood timing (Julian date) (1.5 year flood) FOR FRY
Median flood timing (Julian date) (1.5 year flood) FOR TOTAL
Latitude
Longitude
Drainage area
Julian Date
All data
OK sites

P50_Q25 – Median Julian Day for a 2.5 year return period

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

Median flood timing (Julian date) (2.5 year flood) FOR EGG
Median flood timing (Julian date) (2.5 year flood) FOR FRY
Median flood timing (Julian date) (2.5 year flood) FOR TOTAL
Latitude
Longitude
Drainage area
Julian Date
all data
OK sites

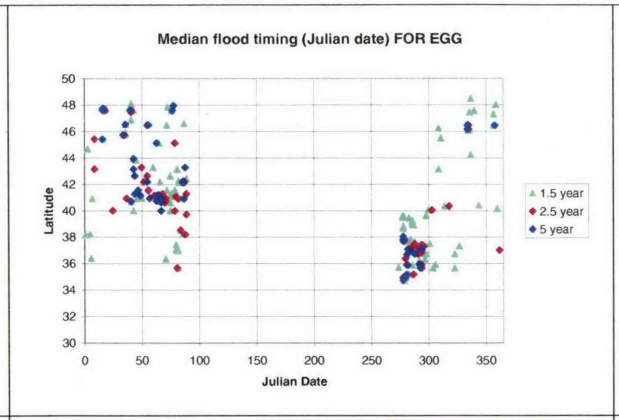
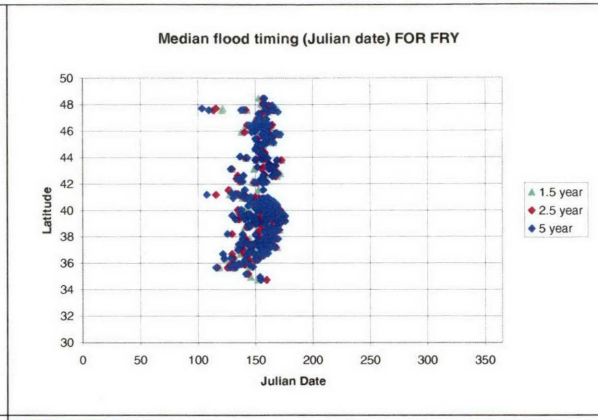
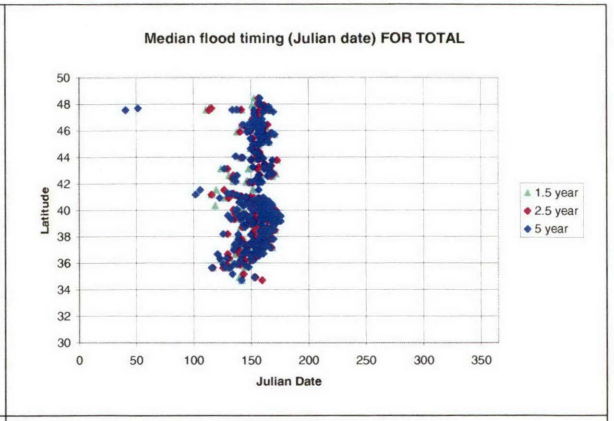
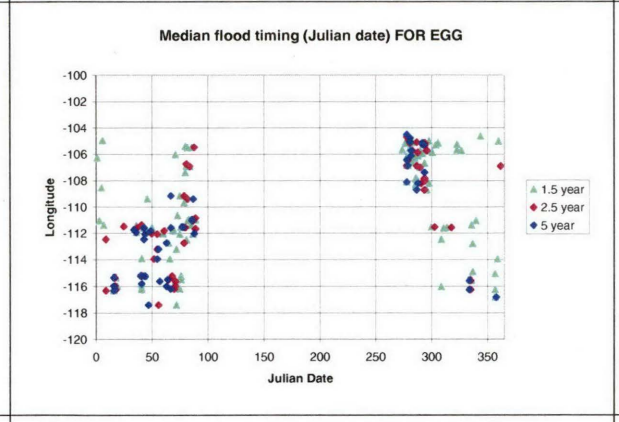
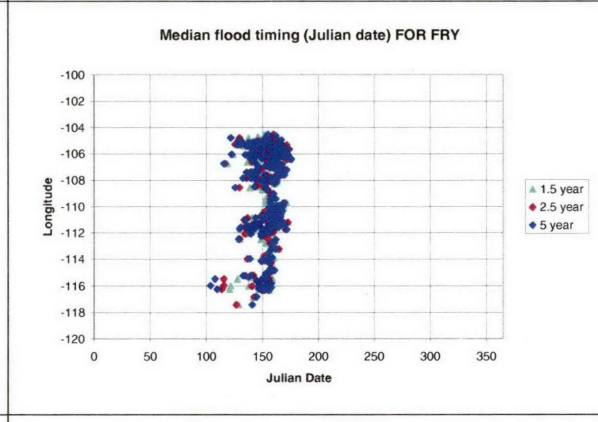
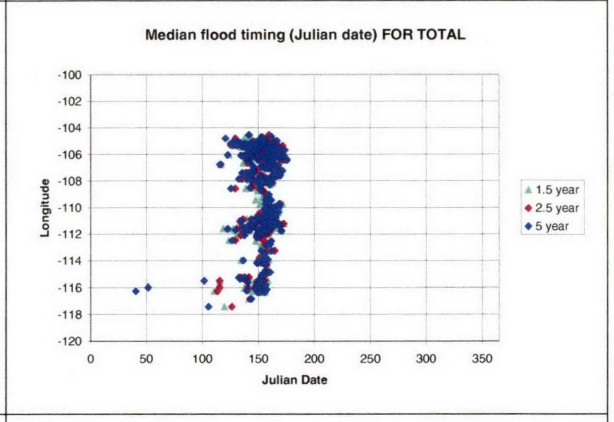
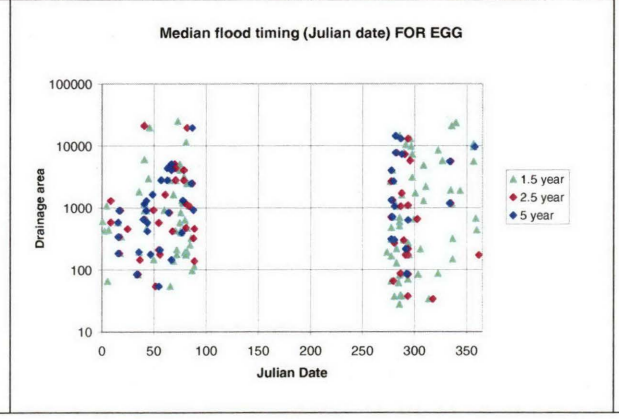
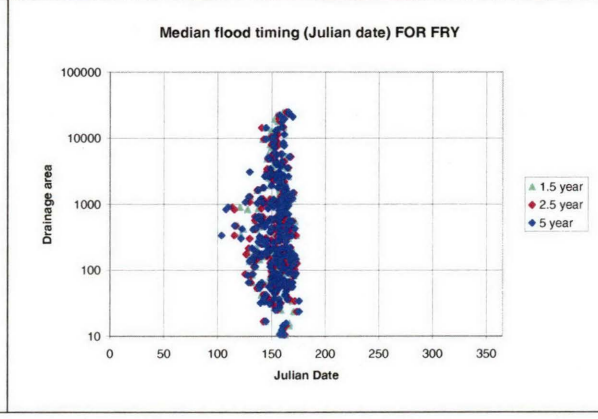
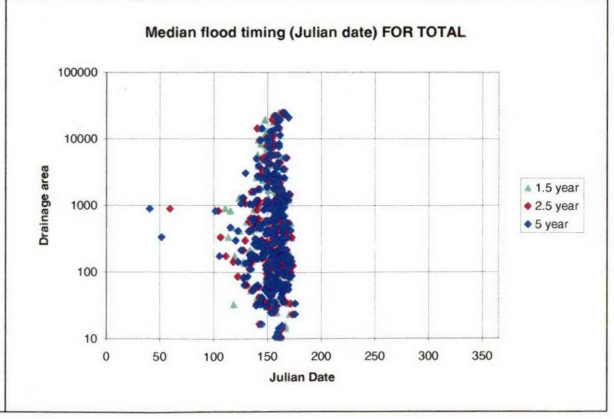
P50_Q5 – Median Julian Day for a 5 year return period

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

Median flood timing (Julian date) (5 year flood) FOR EGG
Median flood timing (Julian date) (5 year flood) FOR FRY
Median flood timing (Julian date) (5 year flood) FOR TOTAL
Latitude
Longitude
Drainage area
Julian Date
all data
OK sites

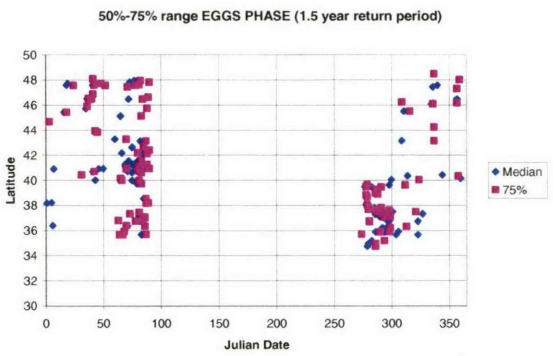
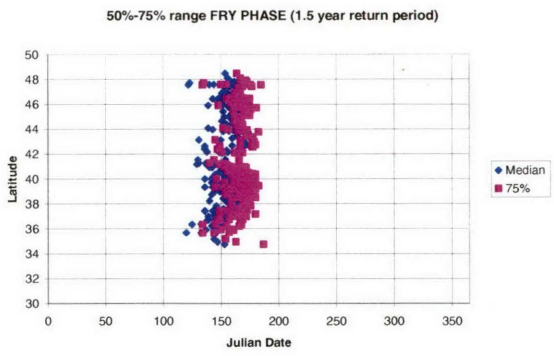
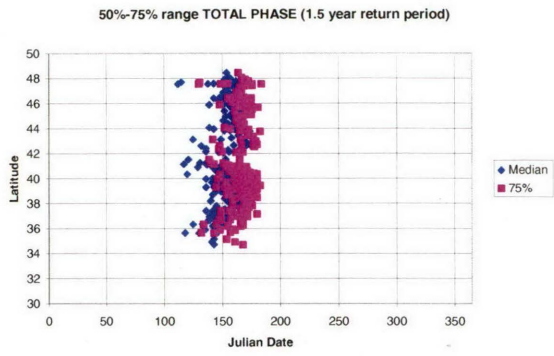
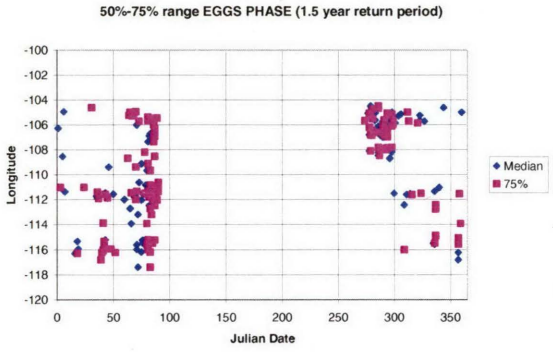
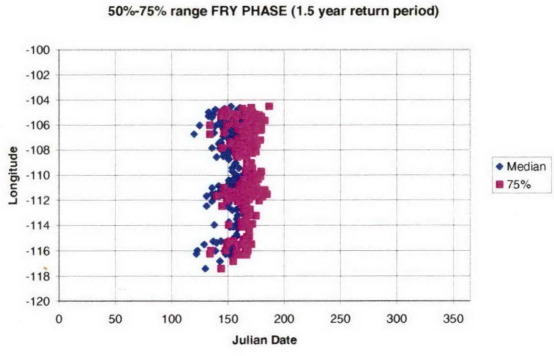
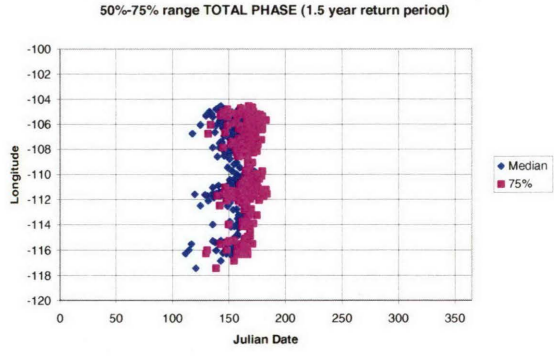
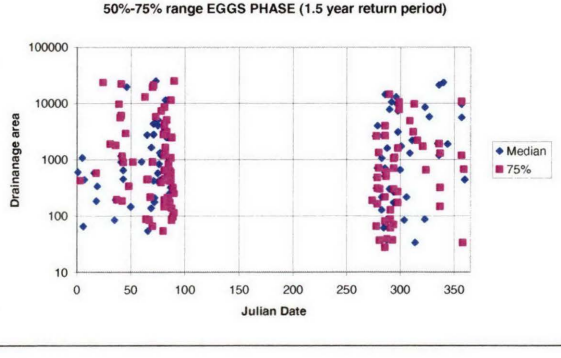
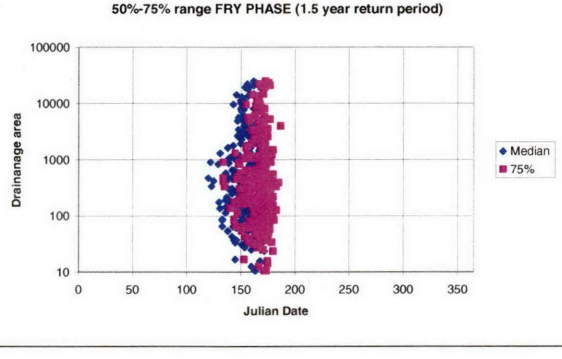
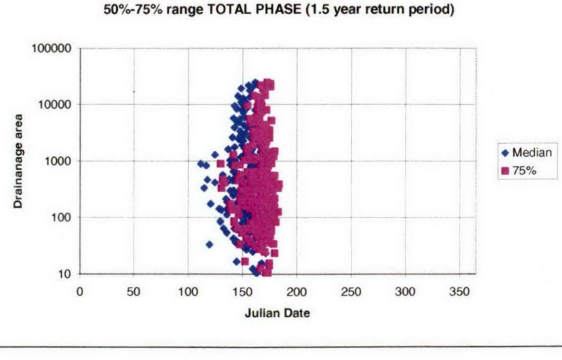
APPENDIX 2

Comparison of median flood timing for different return periods (P50_Q15, P50_Q25, and P50_Q5)

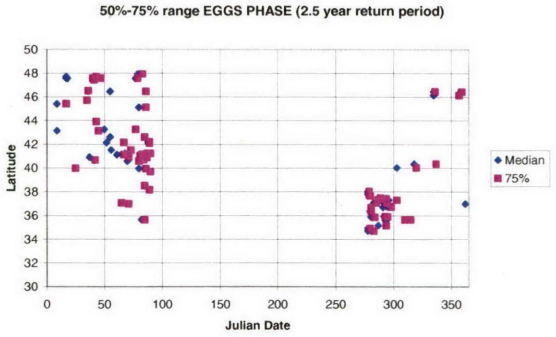
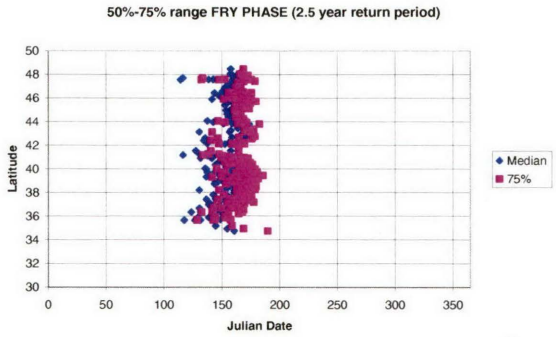
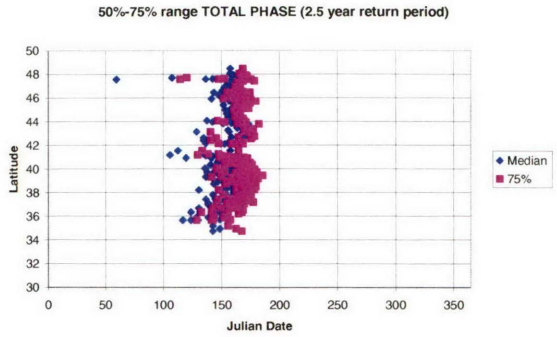
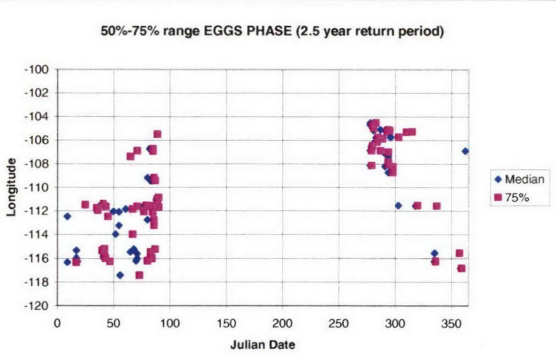
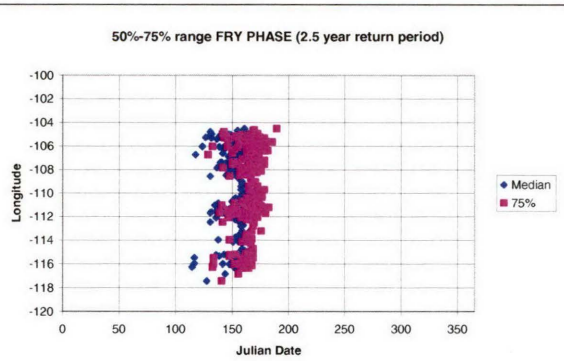
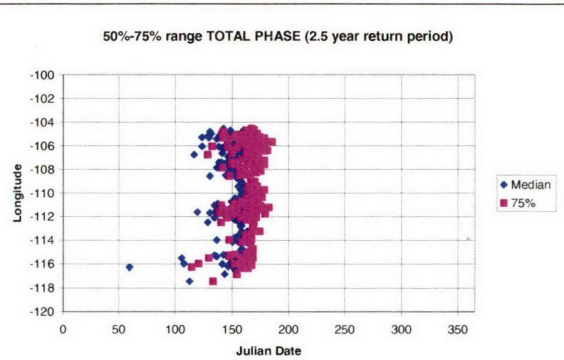
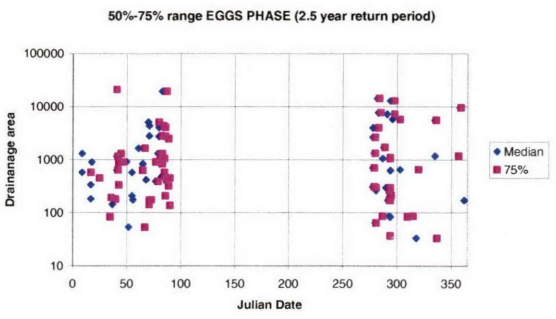
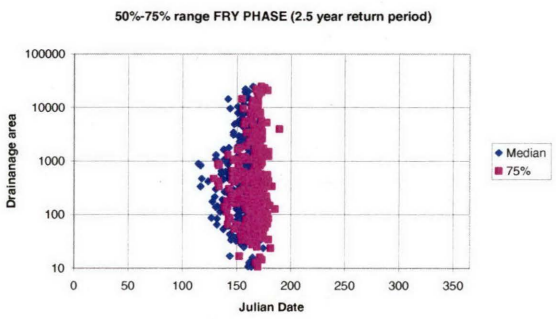
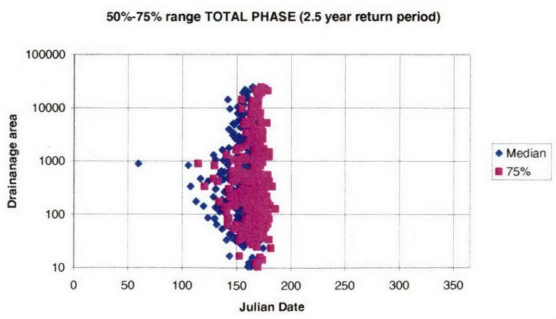
	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

APPENDIX 3

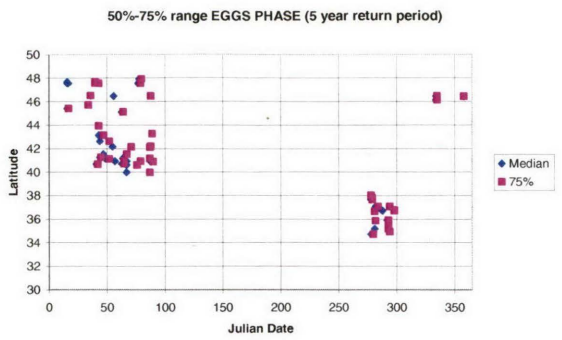
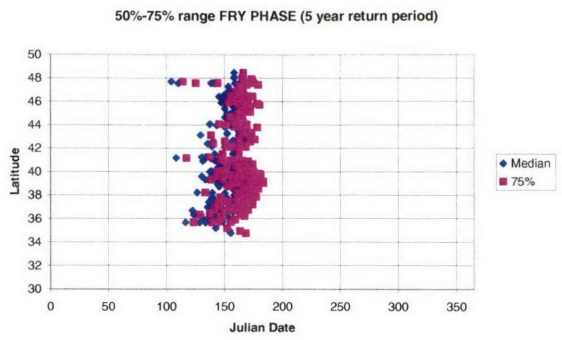
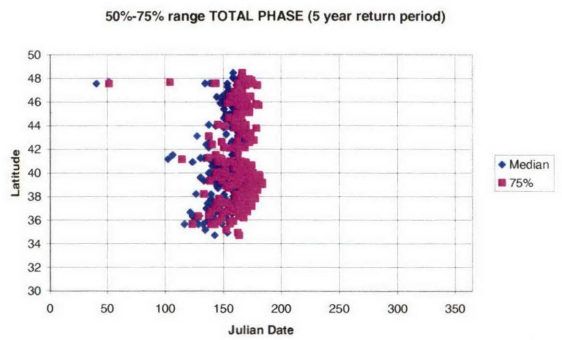
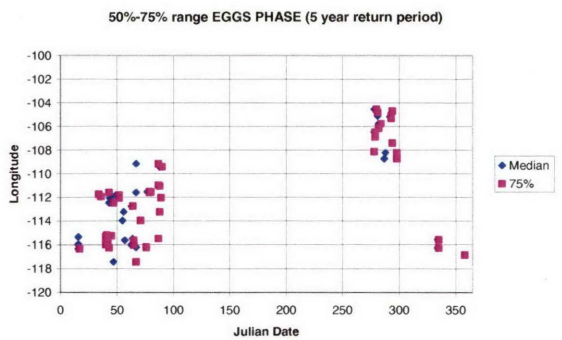
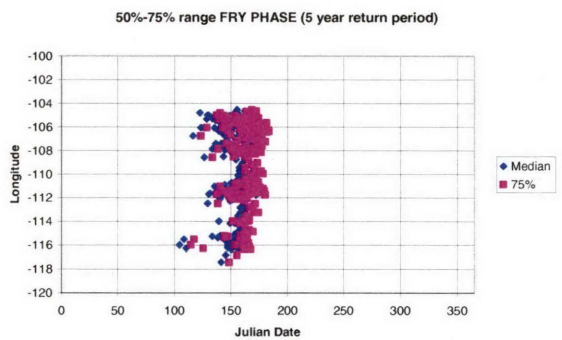
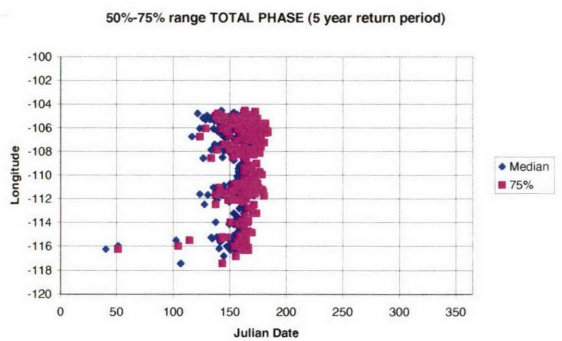
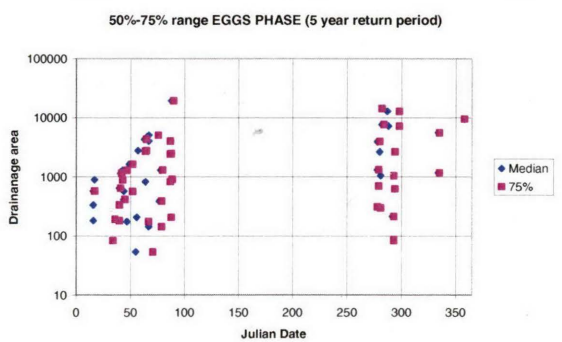
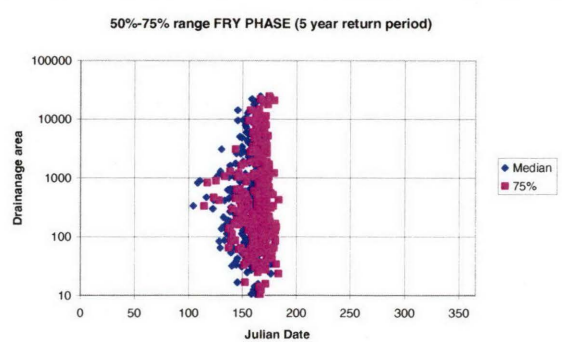
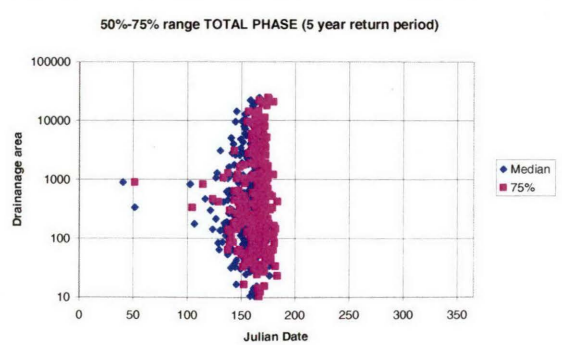
50 – 75% inter-quartile range for flood timing –Julian Days for a 1.5 year return period
variables used: P50_Q15 and P75_Q15

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

50 – 75% inter-quartile range for flood timing –Julian Days for a 2.5 year return period
variables used: P50_Q25 and P75_Q25

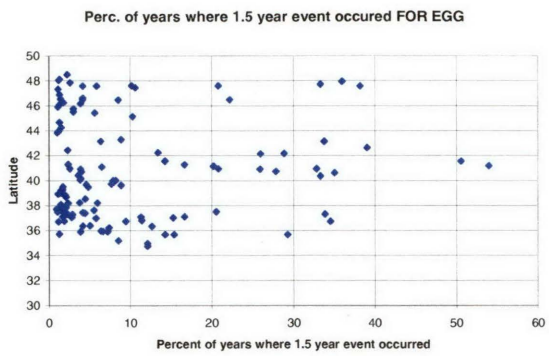
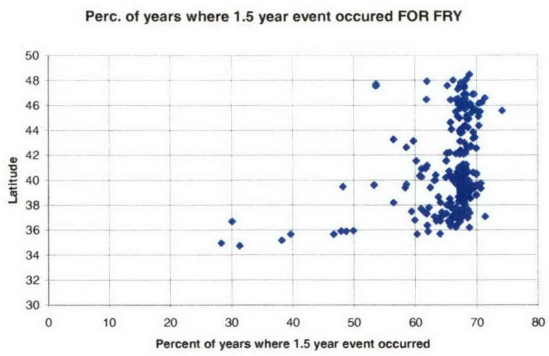
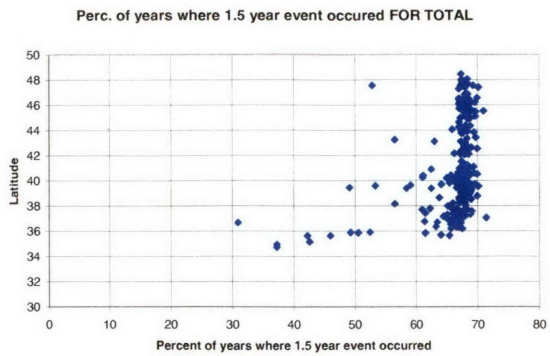
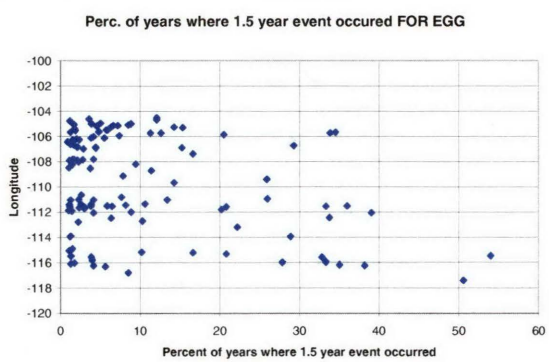
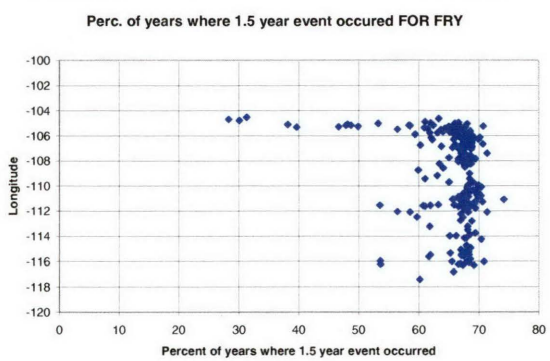
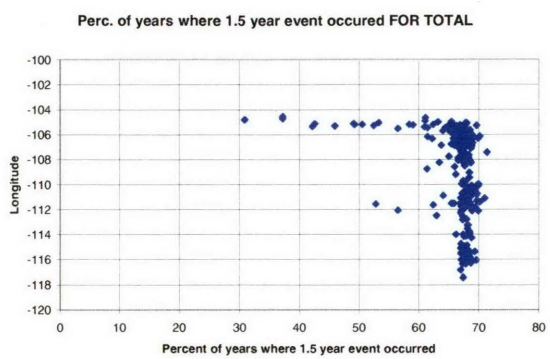
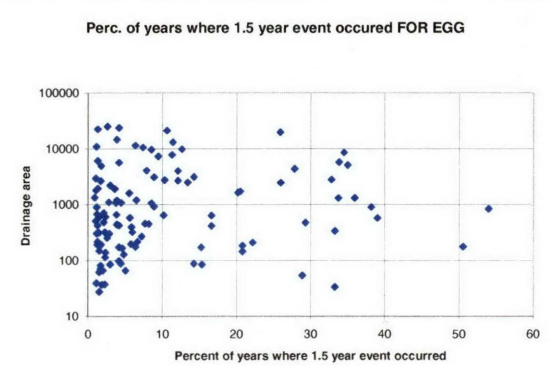
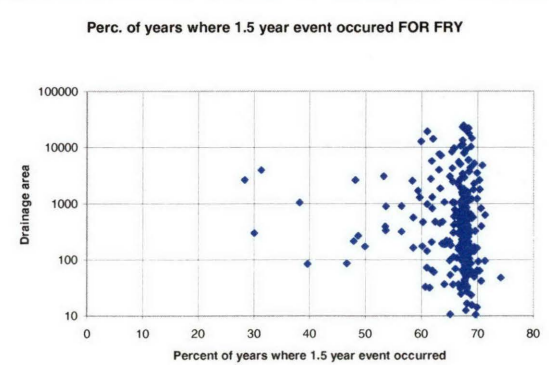
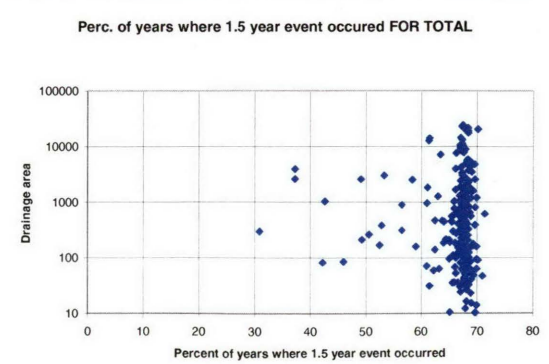
	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

50 – 75% inter-quartile range for flood timing –Julian Days for a 5 year return period
variables used: P50_Q5 and P75_Q5

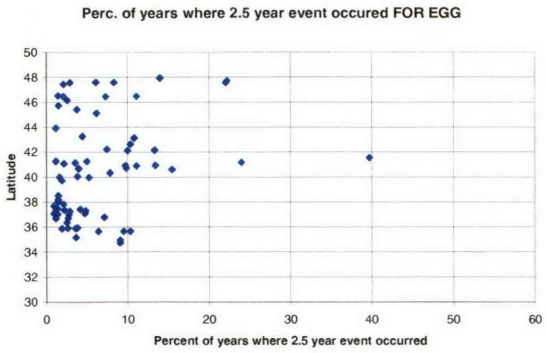
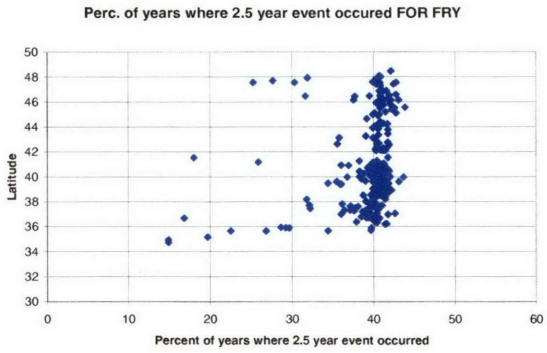
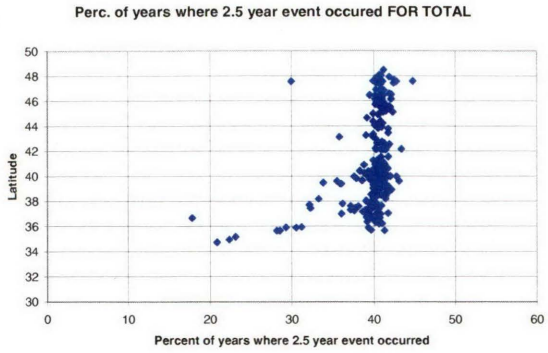
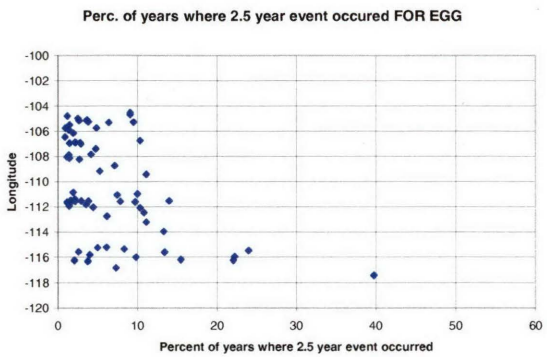
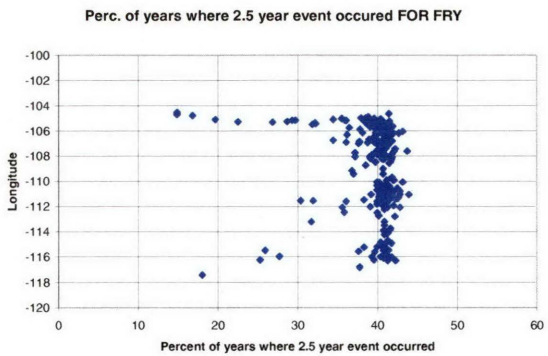
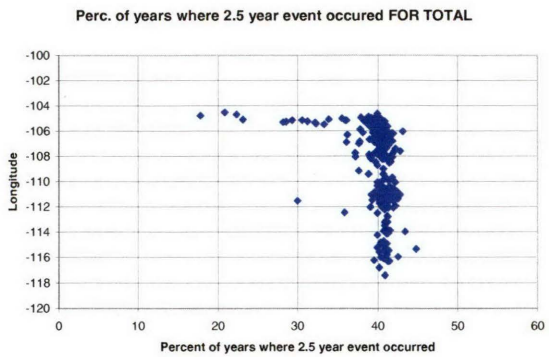
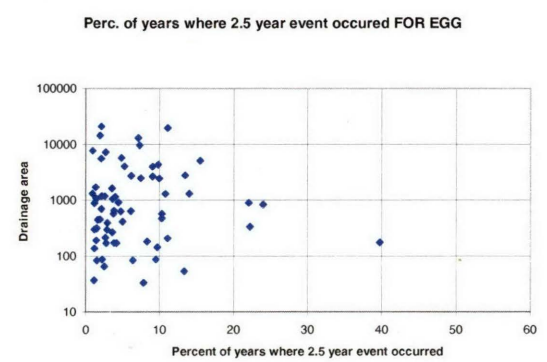
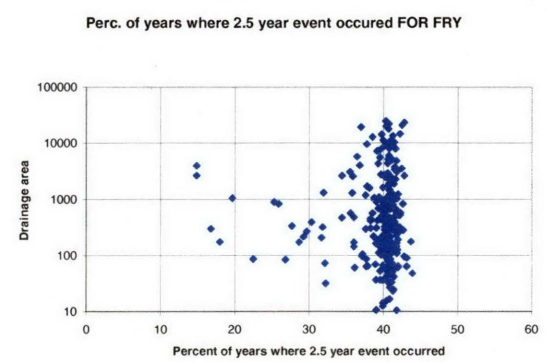
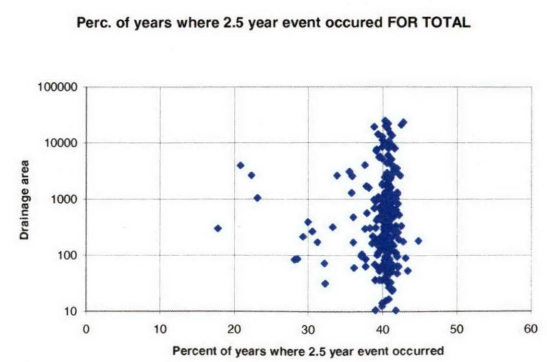
	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

APPENDIX 4

Per15 – Percent of years when 1.5 year event occurred

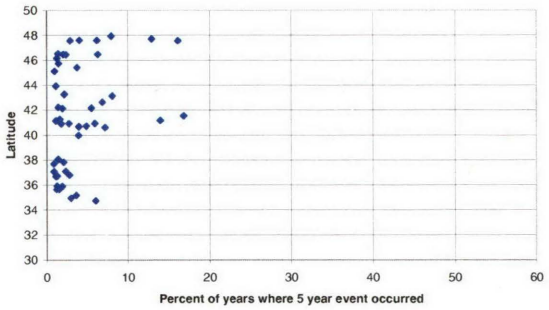
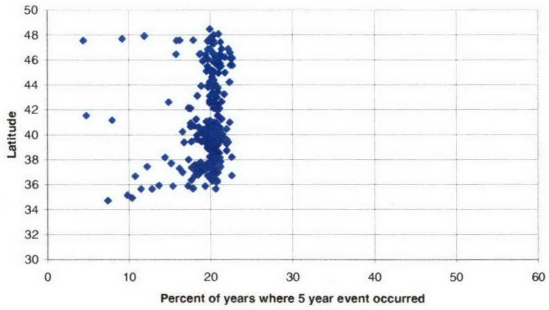
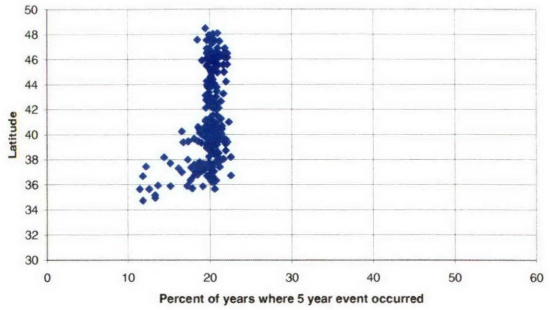
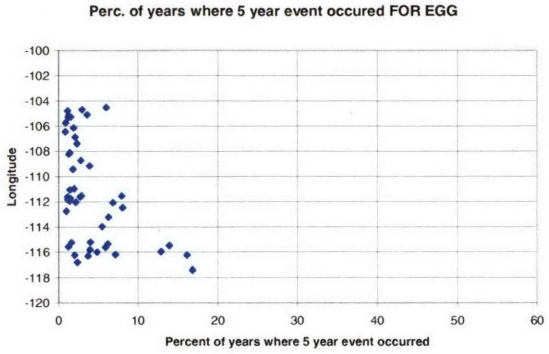
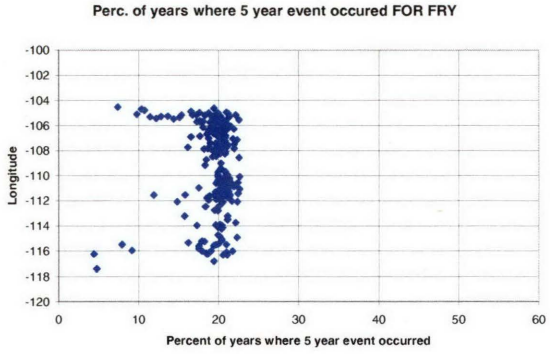
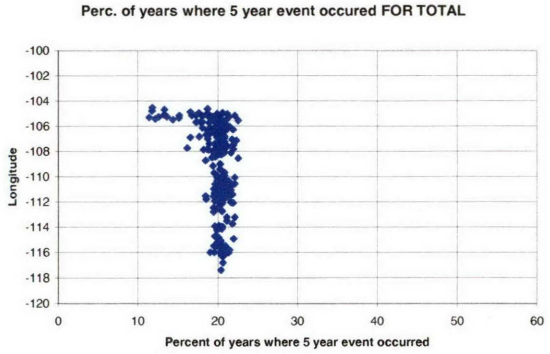
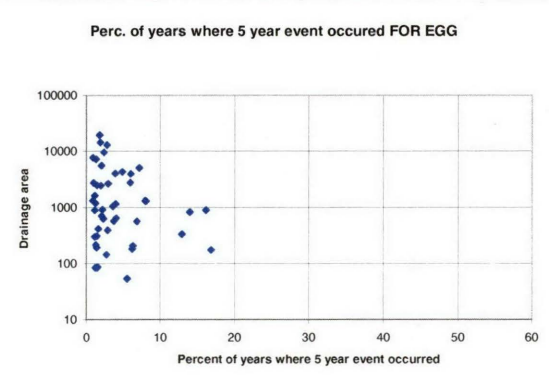
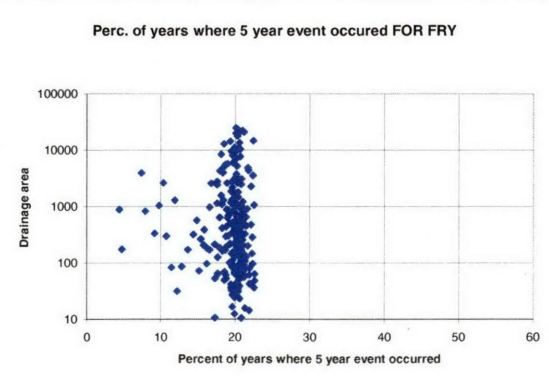
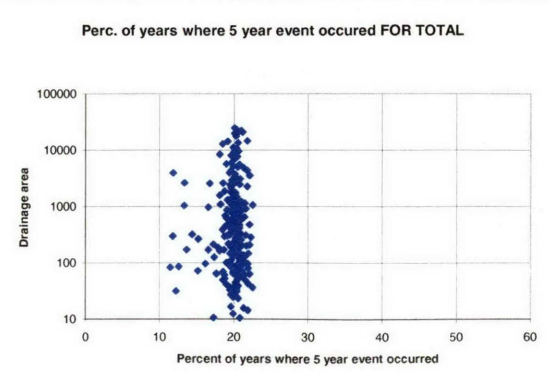
	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

Per25 – Percent of years when 2.5 year event occurred

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

Perc. of years where 2.5 year event occured FOR EGG
Perc. of years where 2.5 year event occured FOR FRY
Perc. of years where 2.5 year event occured FOR TOTAL
Latitude
Longitude
Drainage area
Percent of years where 2.5 year event occurred

Per5 – Percent of years when 5 year event occurred

	EGGS	FRY	TOTAL
Latitude			
Longitude			
Drainage area (mi^2)			

Perc. of years where 5 year event occured FOR EGG
Perc. of years where 5 year event occured FOR FRY
Perc. of years where 5 year event occured FOR TOTAL
Latitude
Longitude
Drainage area
Percent of years where 5 year event occurred